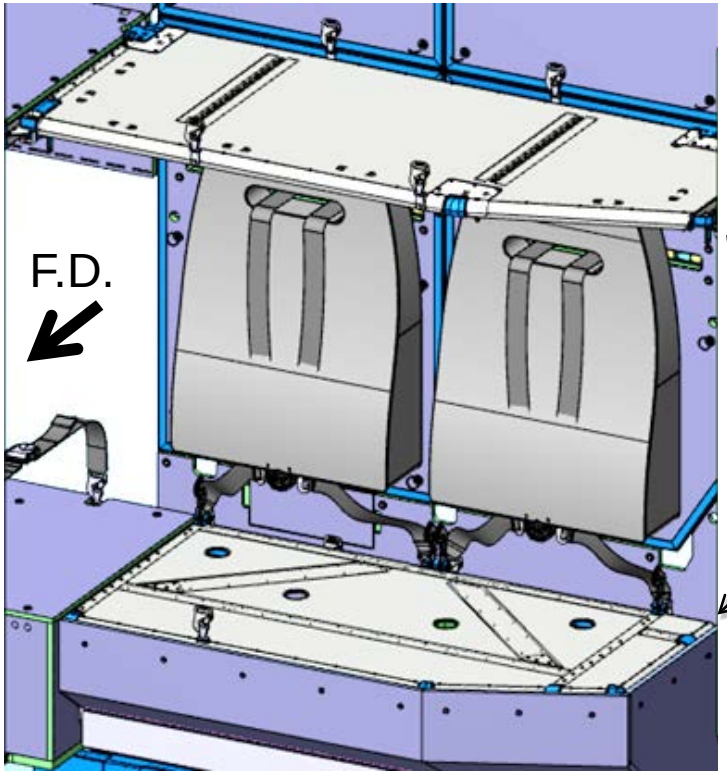
The effectiveness of the dynamic analysis for the crew seat of KC-390 aircraft qualification for emergency landing conditions.

Authors: LOUREIRO, P. L. G. ; COLUS, L. H. M.

HISTORIC



In September 2015, LHColus Technology was contracted by EMBRAER to develop and qualify a double crew seat for KC-390 aircraft, denominated BUNK BED SYSTEM.

- Upper Bed-Assy
- Double Seat-Assy

→ **BUNK BED SYSTEM**

MAIN REQUIREMENTS

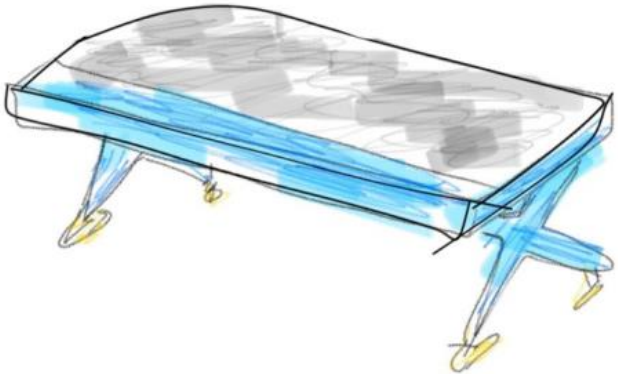
Dynamic Strength
The Double Seat shall meet the dynamic loads requirement of CFR 14 Part 25.562, considering two occupants of each weighing 250 lb. ←
The tests shall be conducted with a 95th percentile VIP-95, Hybrid III or ADAM-type anthropomorphic test dummy weighing 250 lb. ←

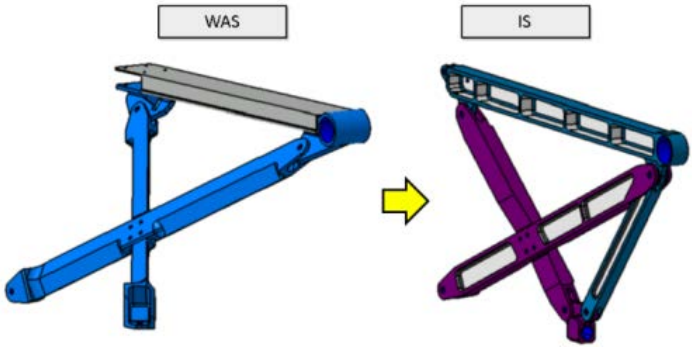
The customer requested a seat for two occupants, each weighing 250 pounds.
This exceeds requirement 14 CFR 25.562, which requires a weighing of 170 pounds for each occupant.

Double Seat Structure + Fairing Target Weight ≤ 37 lb

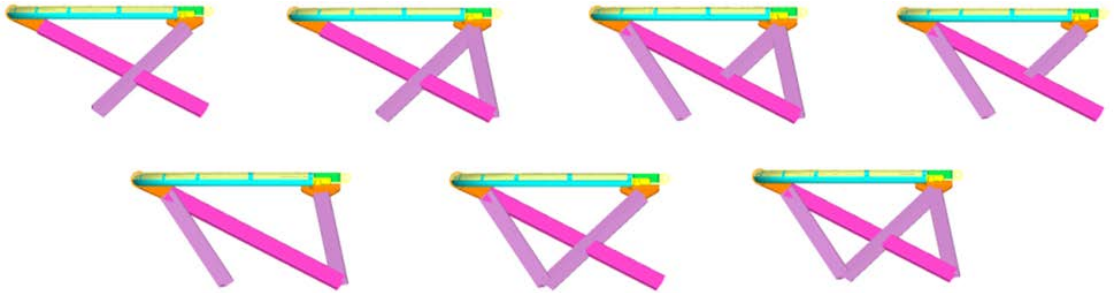
Item	Weight (lb)
Bunk Bed, Instl	33
Fairing, Assy, Bunk Bed	4
Total	37

DEVELOPMENT PHASE





Several seat configurations were evaluated during the development phase with the primary purpose of succeeding in the dynamic tests defined by requirement 14 CFR 25.562.



DEVELOPMENT PHASE

We analyzed a total of 7 different load cases from OCT/2015 to NOV/2016.

Critical Case ↓

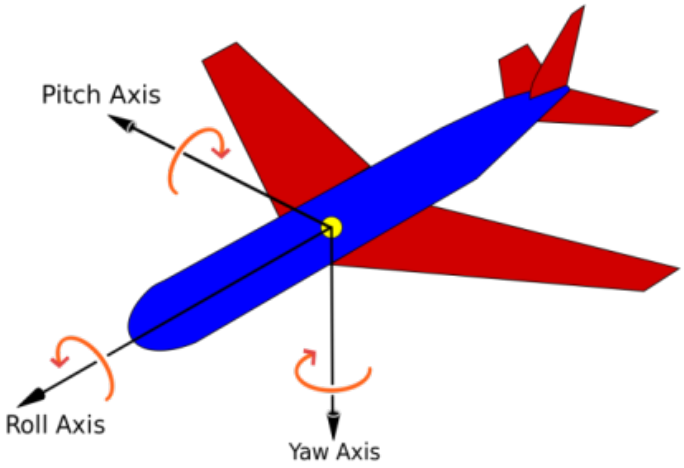
Nº CASE	1	2	3	4	5	6	7
CONDITION	16g + 10° YAW	16g - 10° YAW	16g + 10° YAW	16g - 10° YAW	16g + 10° YAW	16g - 10° YAW	14g + 30° PITCH
DEFORMED FLOOR	- 10° PITCH and +10° ROLL		- 10° PITCH and -10° ROLL		HIC		-

16g FWD Structural Condition

14g DOWN Condition

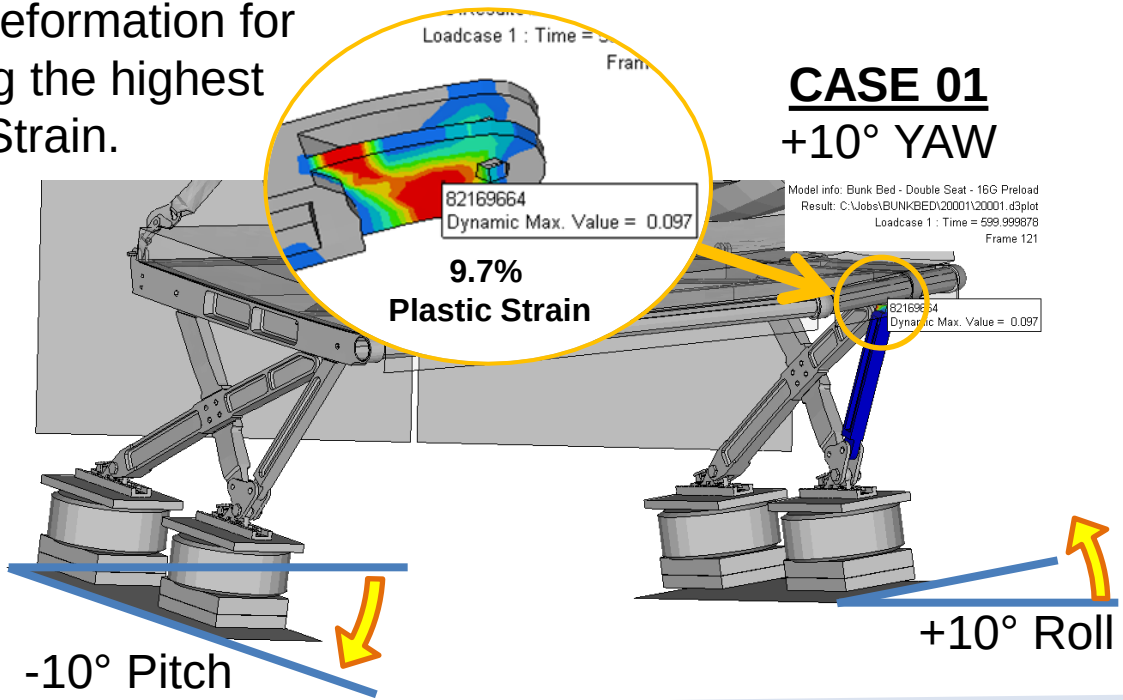
DEVELOPMENT PHASE

The results of the analyzes determined the most critical configuration of the floor deformation for the 16g structural test, indicating the highest value of 9.7% of Plastic Strain.



CASE 01

+10° YAW

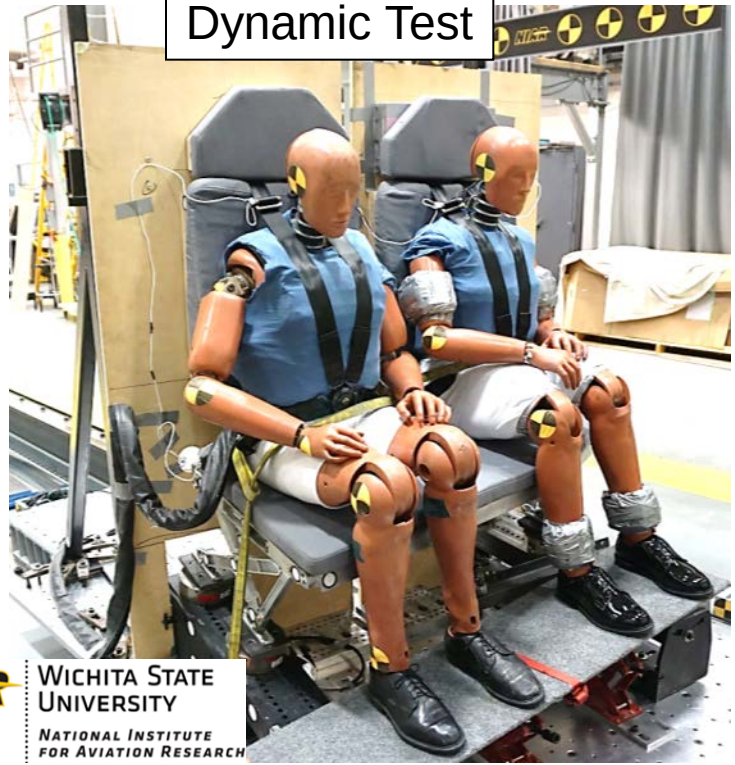


16g CONDITION

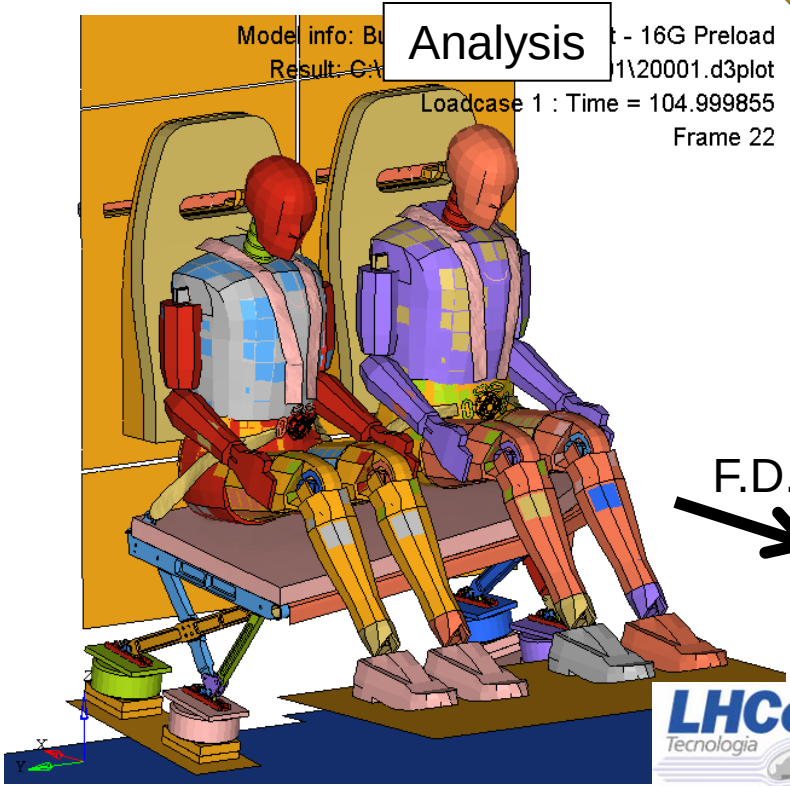
The 16g dynamic test was performed at the National Institute for Aviation Research (NIAR) laboratory in Wichita/KS on January 6 th, 2017.

16g Structural + HIC Test 14CRF 25.562

Dynamic Test



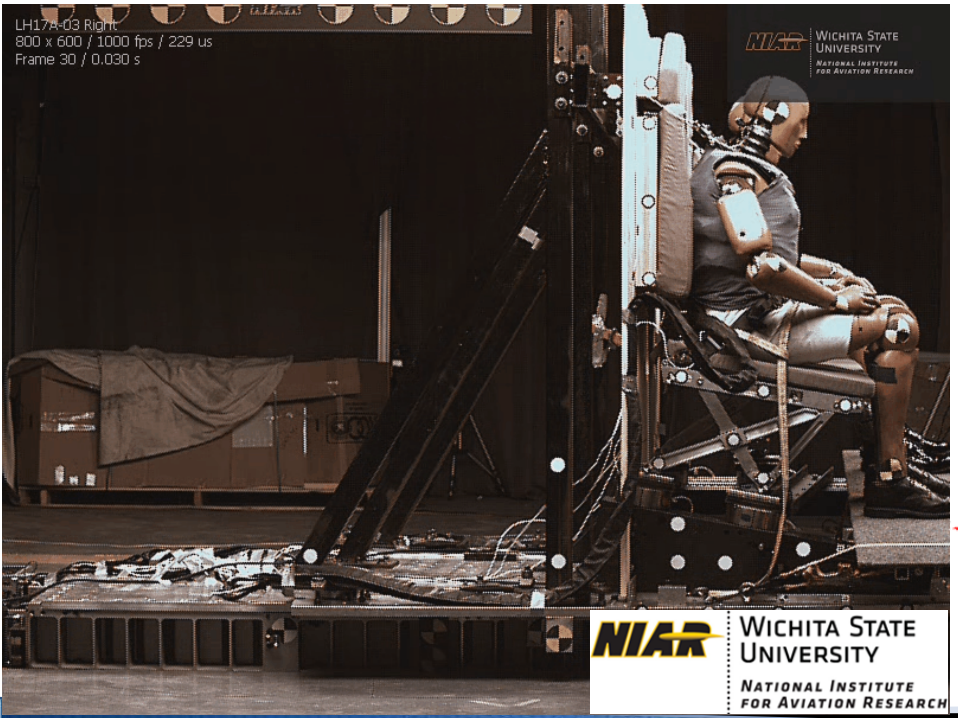
Analysis



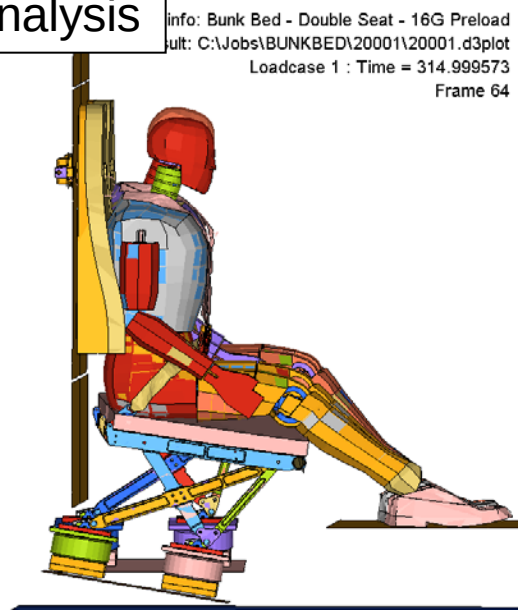
NIAR Wichita State University National Institute for Aviation Research

16g Structural + HIC Test 14CRF 25.562

Dynamic Test



Analysis

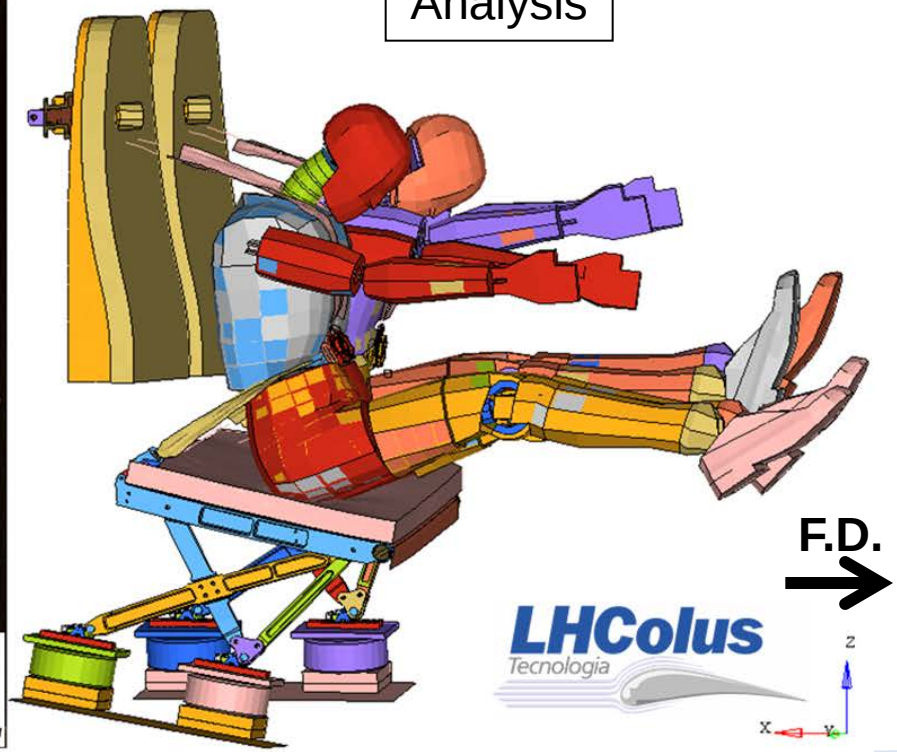


F.D.

16g Structural + HIC Test 14 CRF 25.562

Dynamic Test

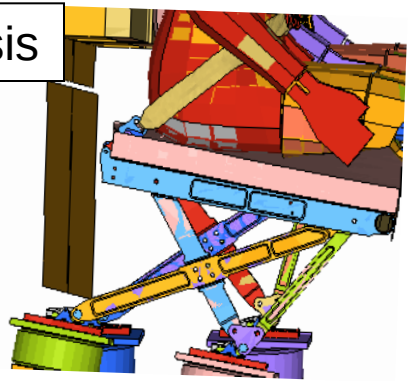
Analysis



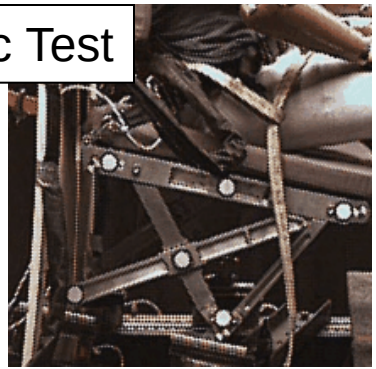
16g Structural + HIC Test 14 CRF 25.562

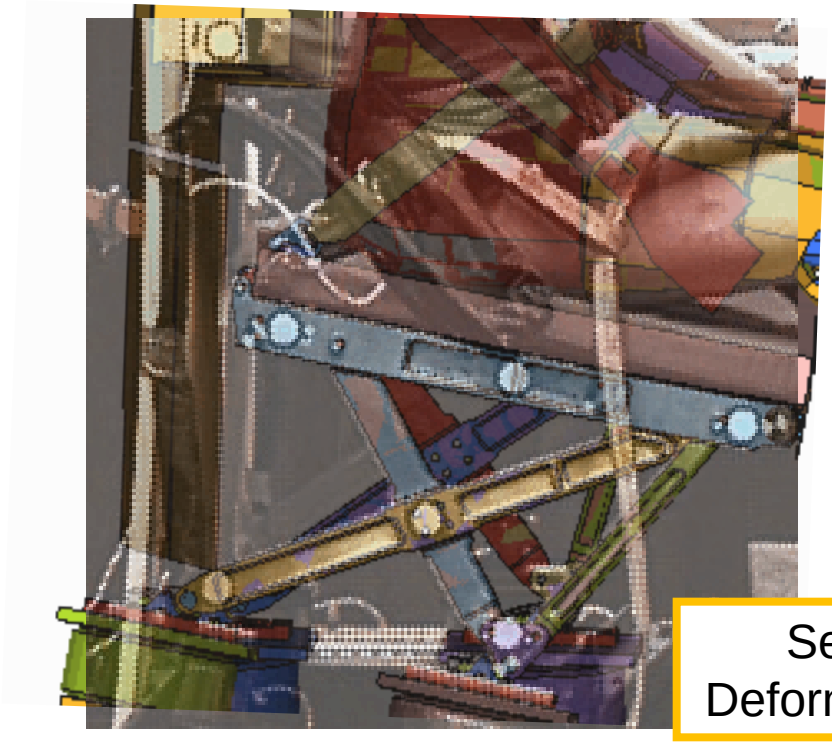
Analysis

F.D.



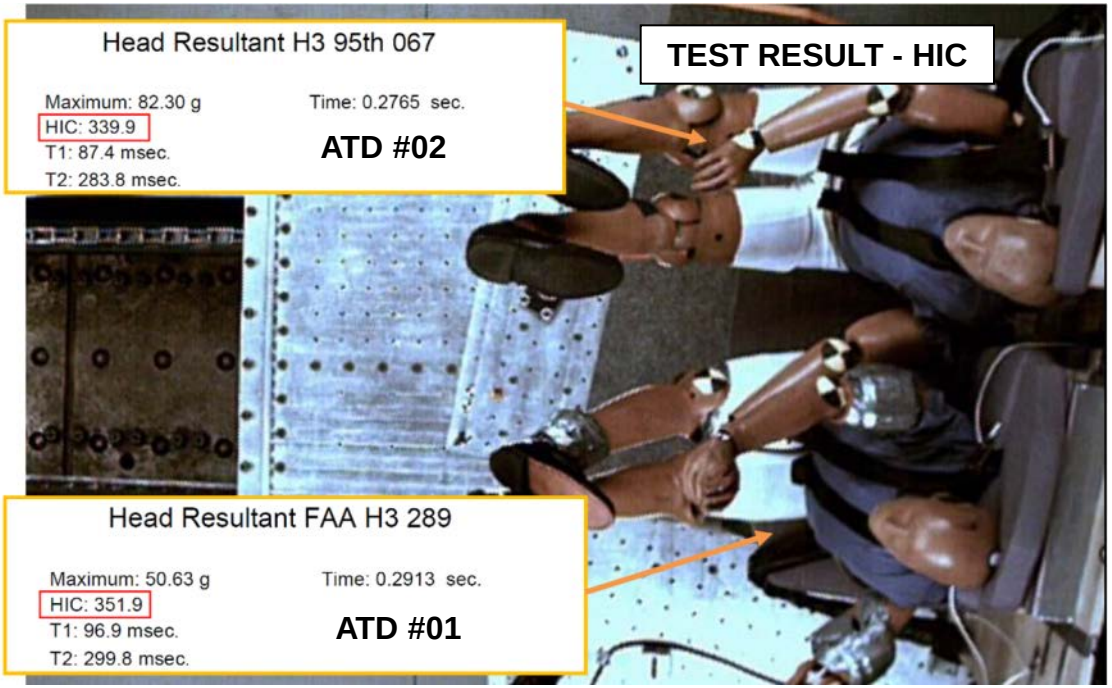
Dynamic Test

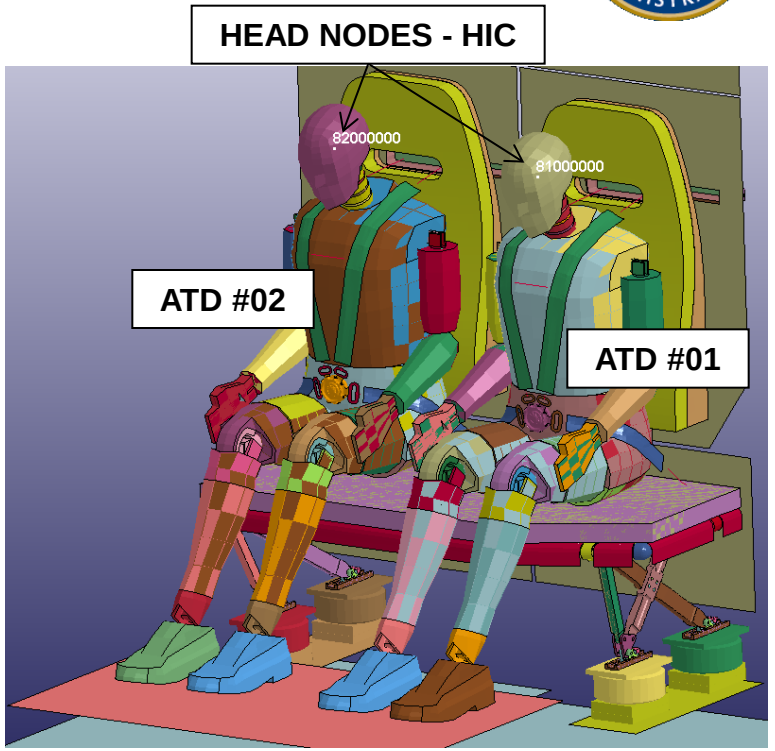




Seat Deformation

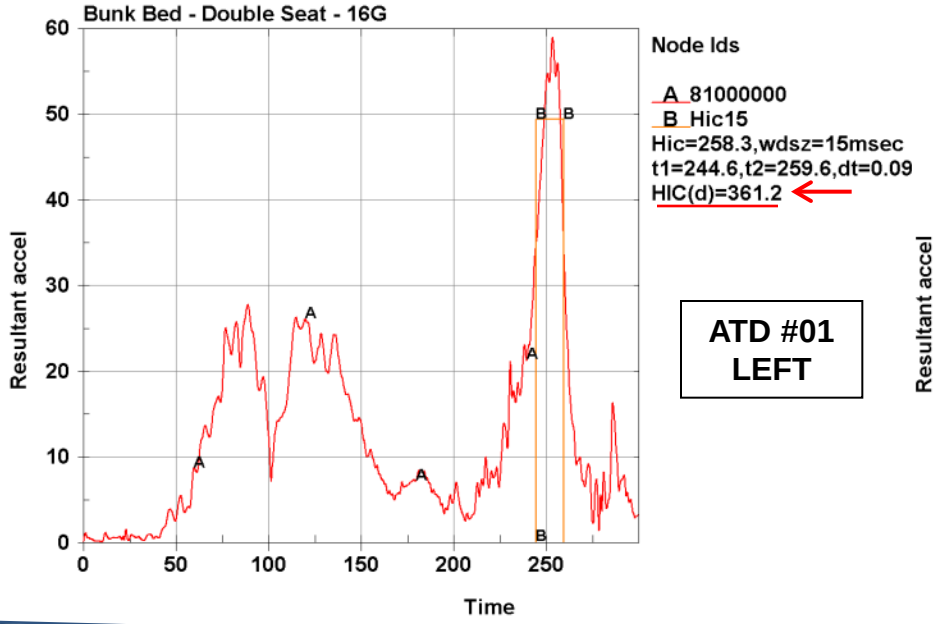
HIC - Head Injury Criterion



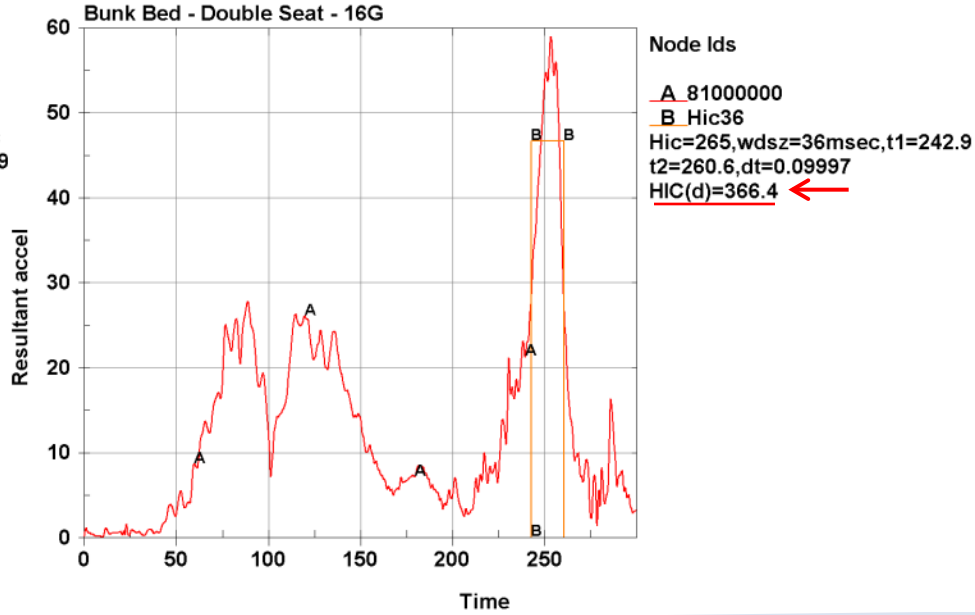


HIC - Head Injury Criterion

HIC - Head Injury Criterion					
DUMMY	ANALYSIS		TEST	DIFFERENCE TEST X ANALYSIS	
	HIC 15	HIC 36	HIC	HIC 15	HIC 36
ATD #01	361	366	352	3%	4%

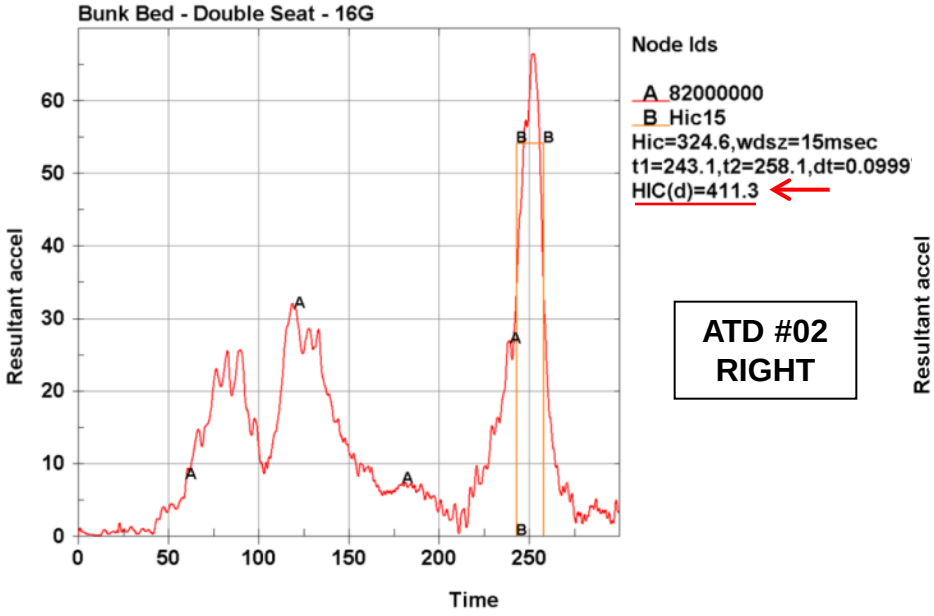


ATD #01 LEFT

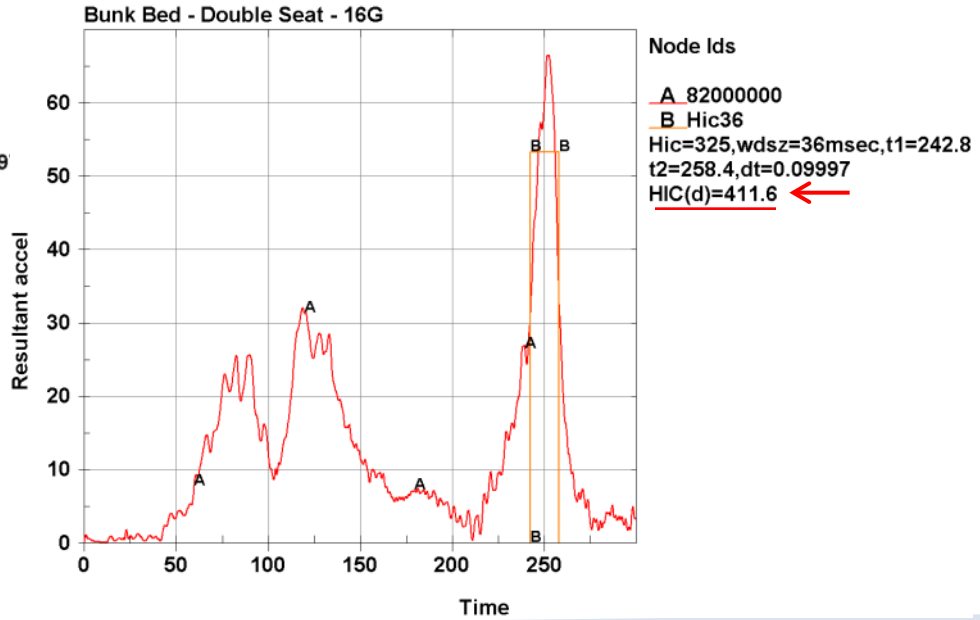


HIC - Head Injury Criterion

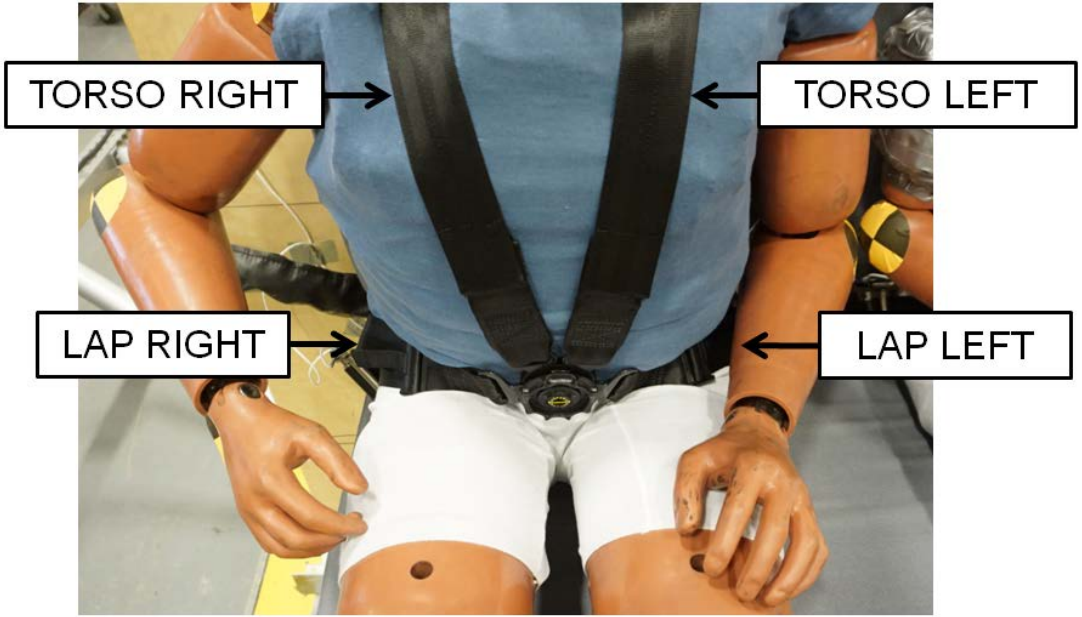
HIC - Head Injury Criterion					
DUMMY	ANALYSIS		TEST	DIFFERENCE TEST X ANALYSIS	
	HIC 15	HIC 36	HIC	HIC 15	HIC 36
ATD #02	411	412	340	21%	21%



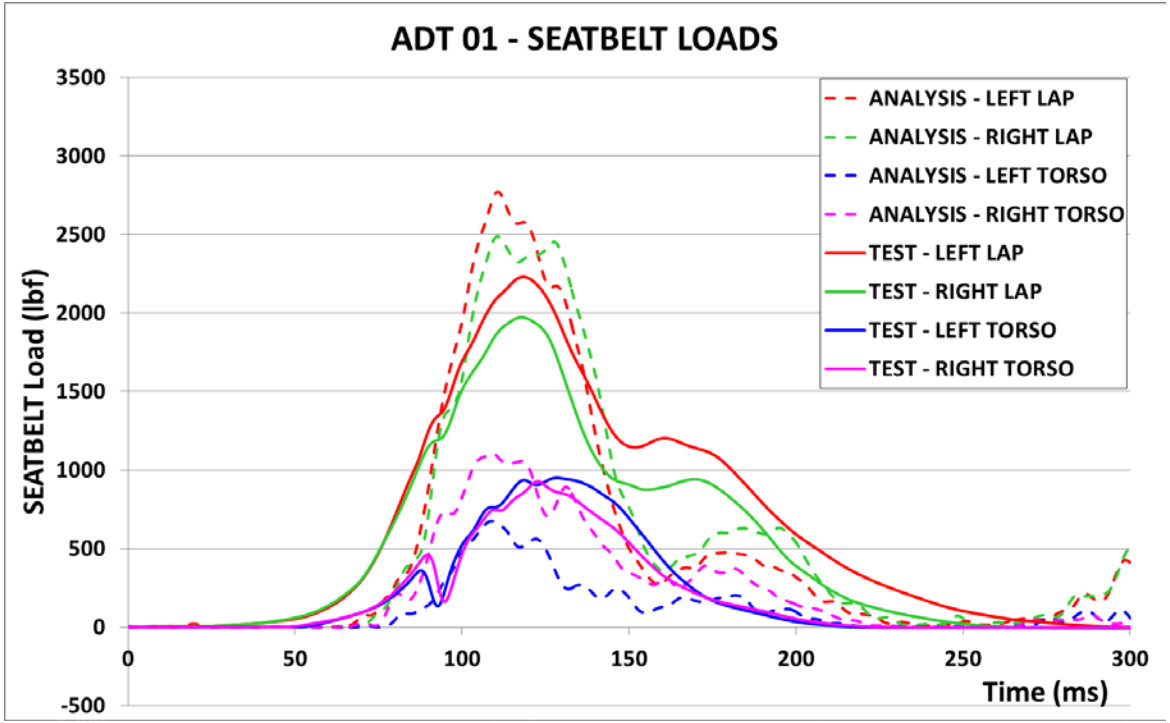
ATD #02 RIGHT



Seat Belt Loads - 16g Structural



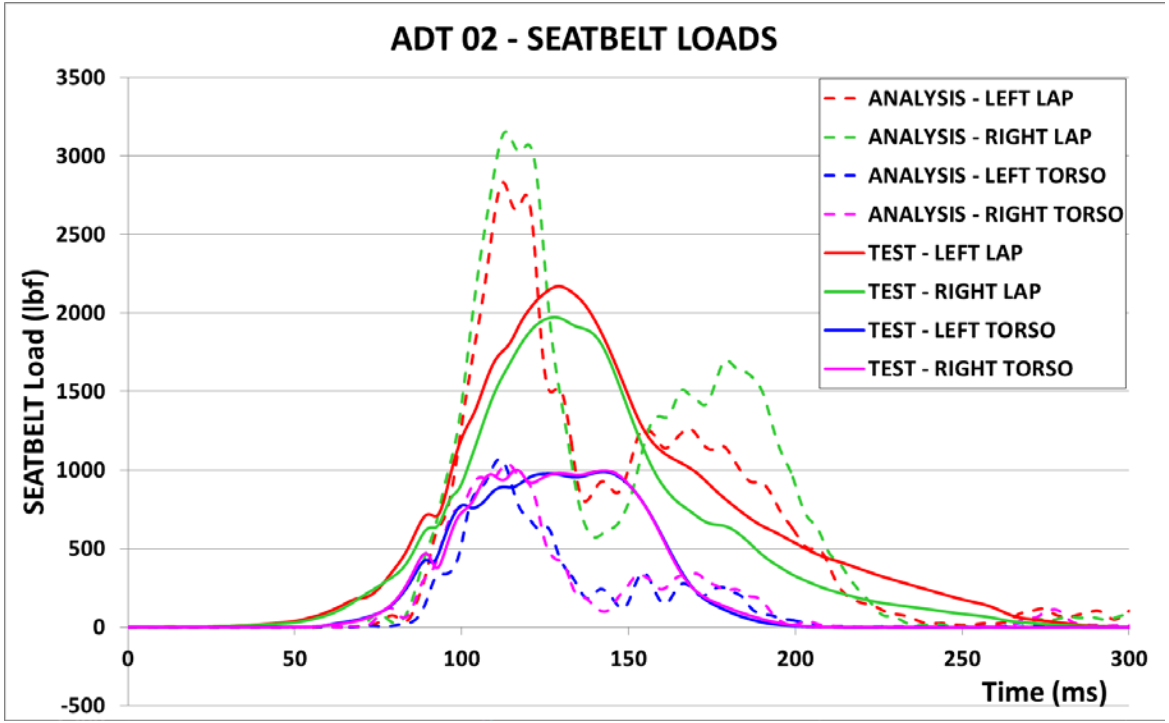
Seat Belt Loads - 16g Structural



MAXIMUM SEATBELT LOADS - ATD 01			
POSITION	SEATBELT LOAD (lbf)		DIFFERENCE (%)
	ANALYSIS	TEST	
LEFT LAP	2773	2231	24%
RIGHT LAP	2487	1973	26%
LEFT TORSO	675	951	-29%
RIGHT TORSO	1105	928	19%

STATISTICS	LOAD (lbf)		DIFFERENCE (%)
	ANALYSIS	TEST	
TOTAL LOAD	7040	6083	16%
TORSO LOAD	1779	1880	-5%
LAP LOAD	5260	4203	25%
TORSO LOAD PERCENTAGE	25%	31%	-
LAP LOAD PERCENTAGE	75%	69%	

Seat Belt Loads - 16g Structural



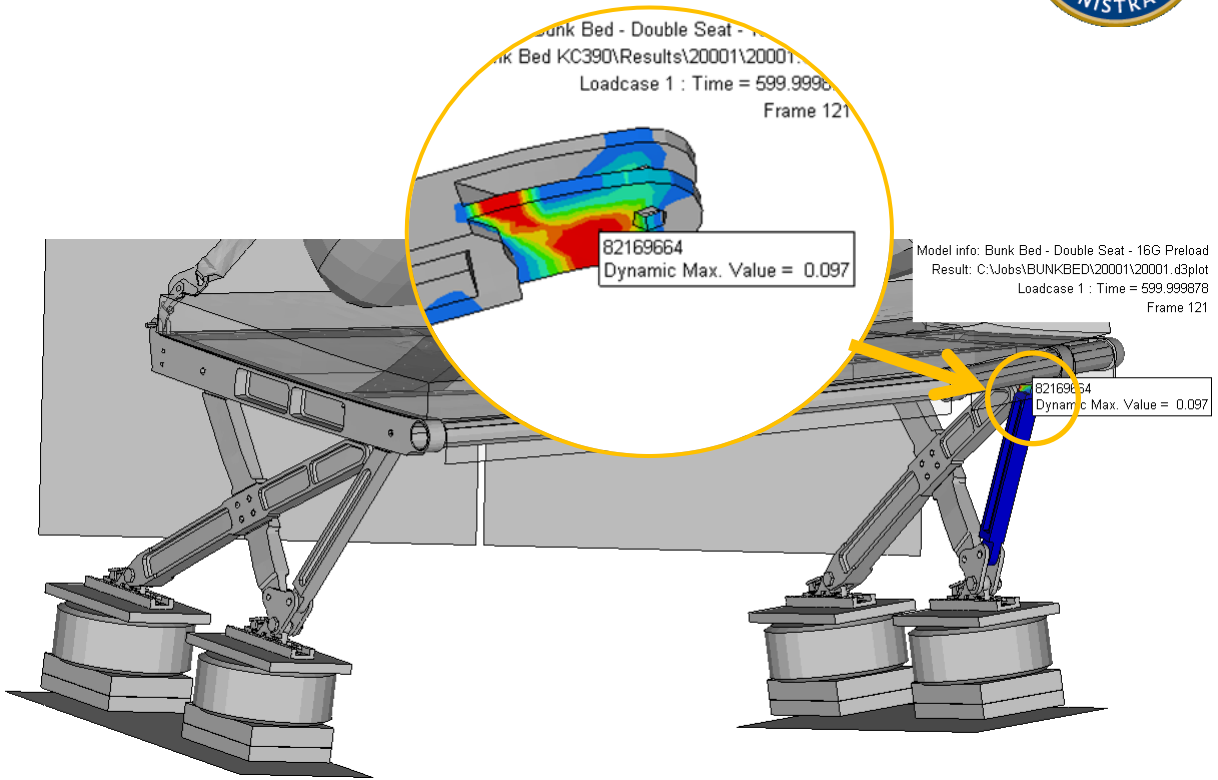
MAXIMUM SEATBELT LOADS - ATD 02			
POSITION	SEATBELT LOAD (lbf)		DIFFERENCE (%)
	ANALYSIS	TEST	
LEFT LAP	2832	2170	30%
RIGHT LAP	3155	1973	60%
LEFT TORSO	1070	990	8%
RIGHT TORSO	1037	1001	4%

STATISTICS	LOAD (lbf)		DIFFERENCE (%)
	ANALYSIS	TEST	
TOTAL LOAD	8094	6133	32%
TORSO LOAD	2107	1990	6%
LAP LOAD	5987	4143	45%
TORSO LOAD PERCENTAGE	26%	32%	-
LAP LOAD PERCENTAGE	74%	68%	

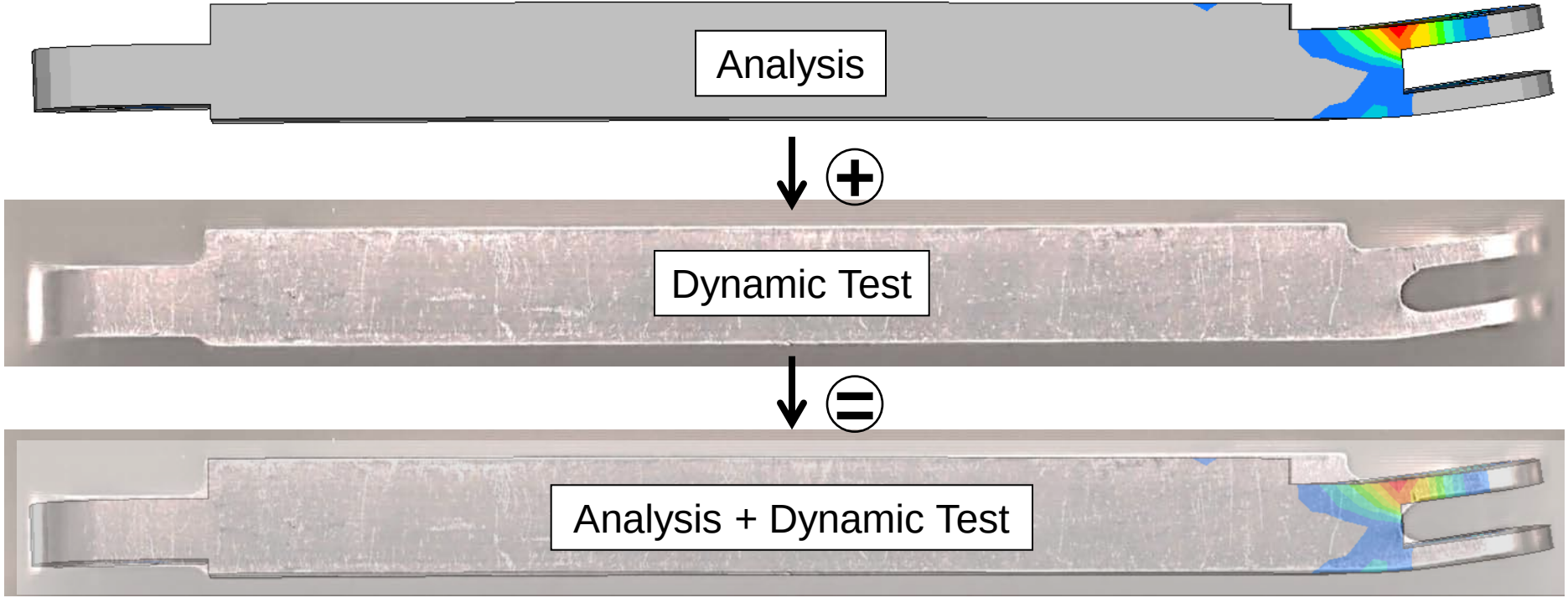
Deformations - 16g Structural

Do you remember the most critical deformation found in the analysis of the 16g structural case presented at the beginning?

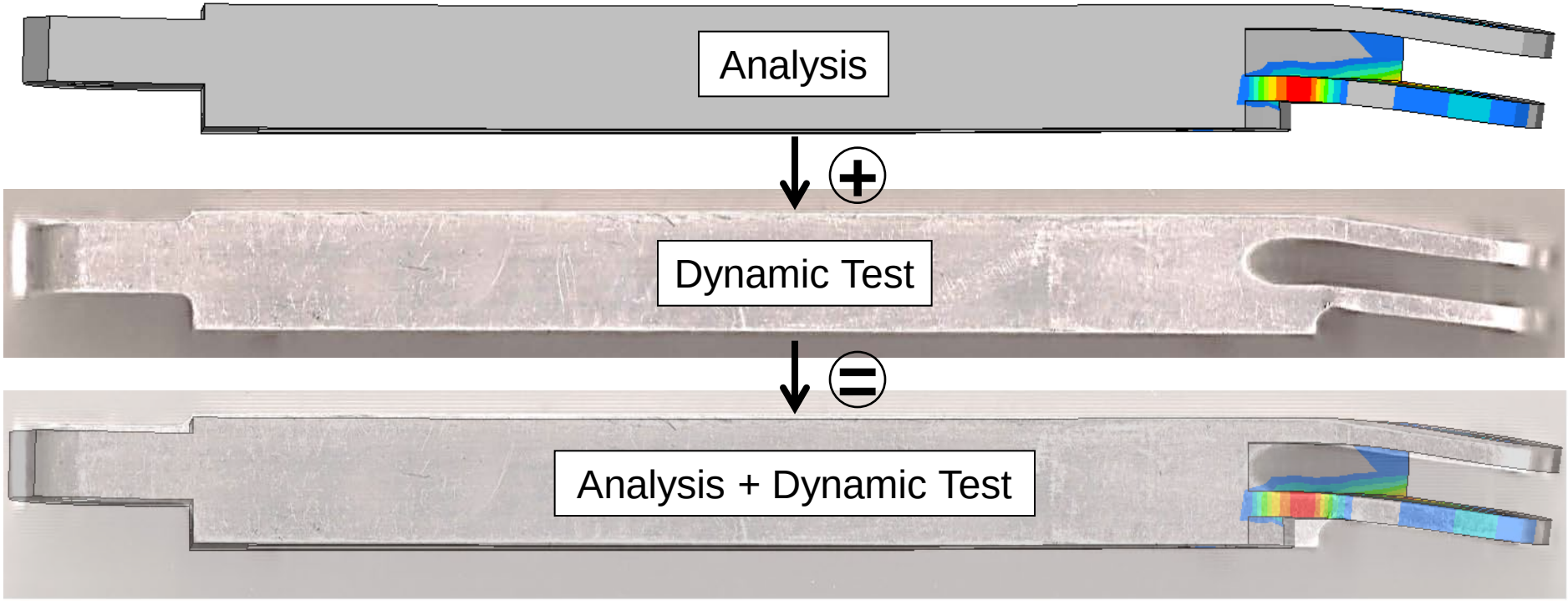
There was the deformed component after the test!



Deformations - 16g Structural



Deformations - 16g Structural

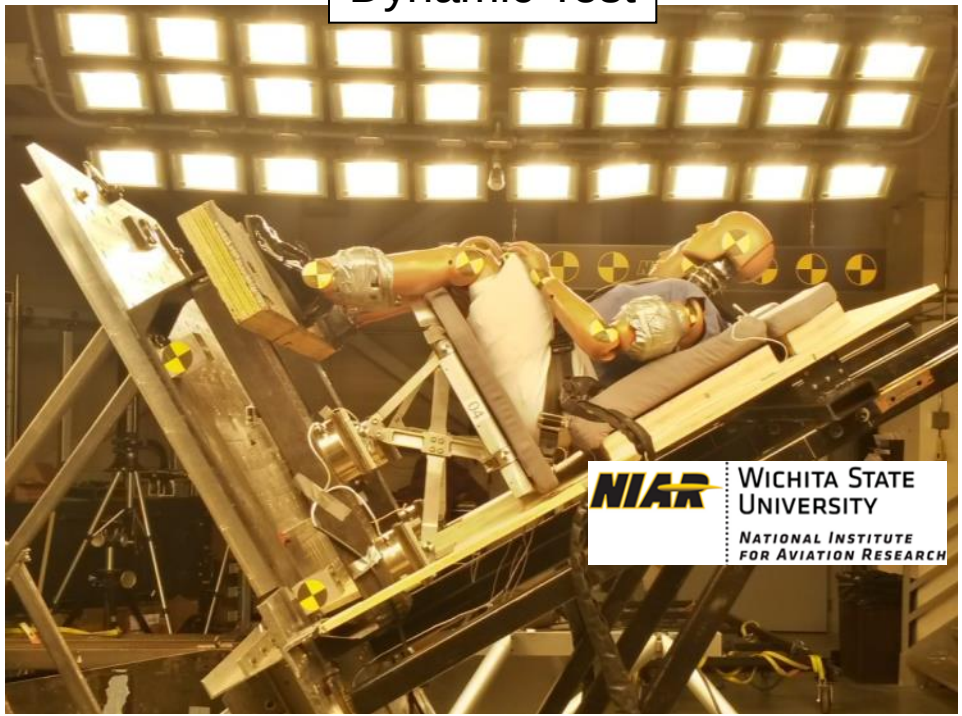


14g CONDITION

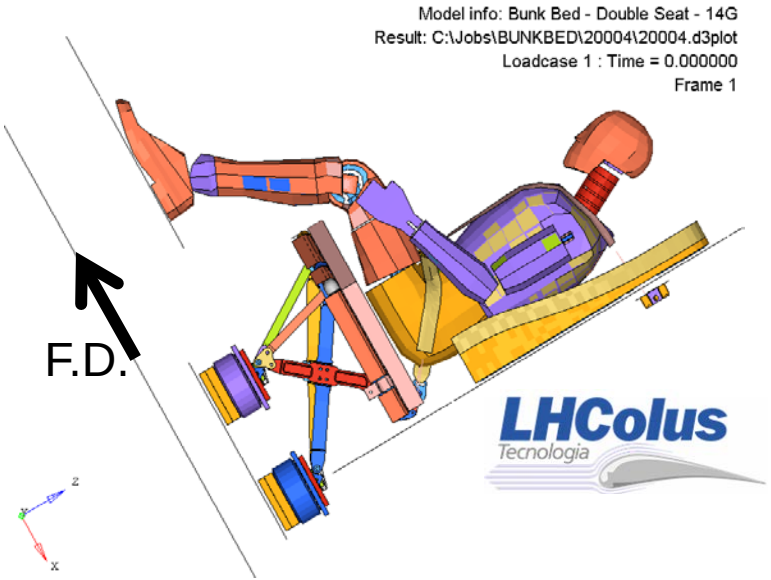
The 14g dynamic test was performed at the National Institute for Aviation Research (NIAR) laboratory in Wichita/KS on January 5 th, 2017.

14g Dynamic Test – 14 CRF 25.562

Dynamic Test

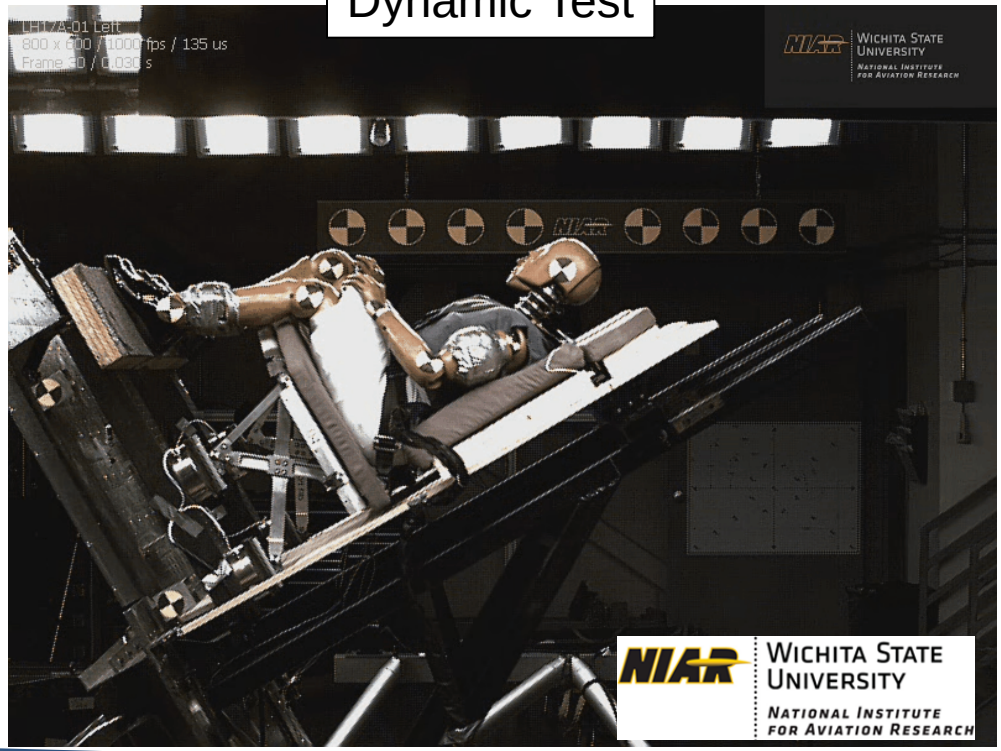


Analysis



14g Dynamic Test – 14 CRF 25.562

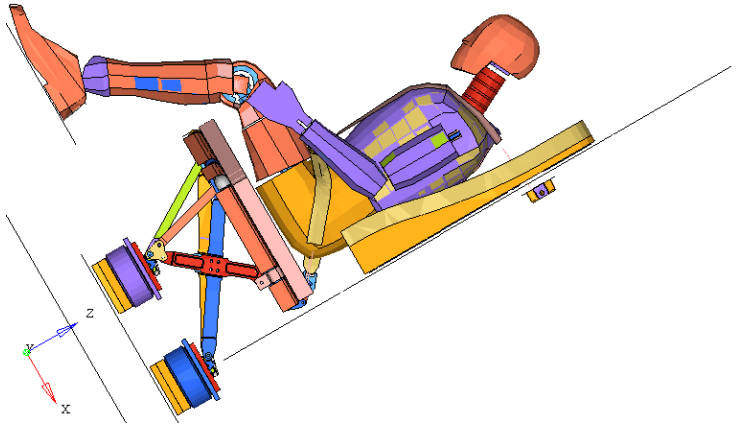
Dynamic Test



Analysis

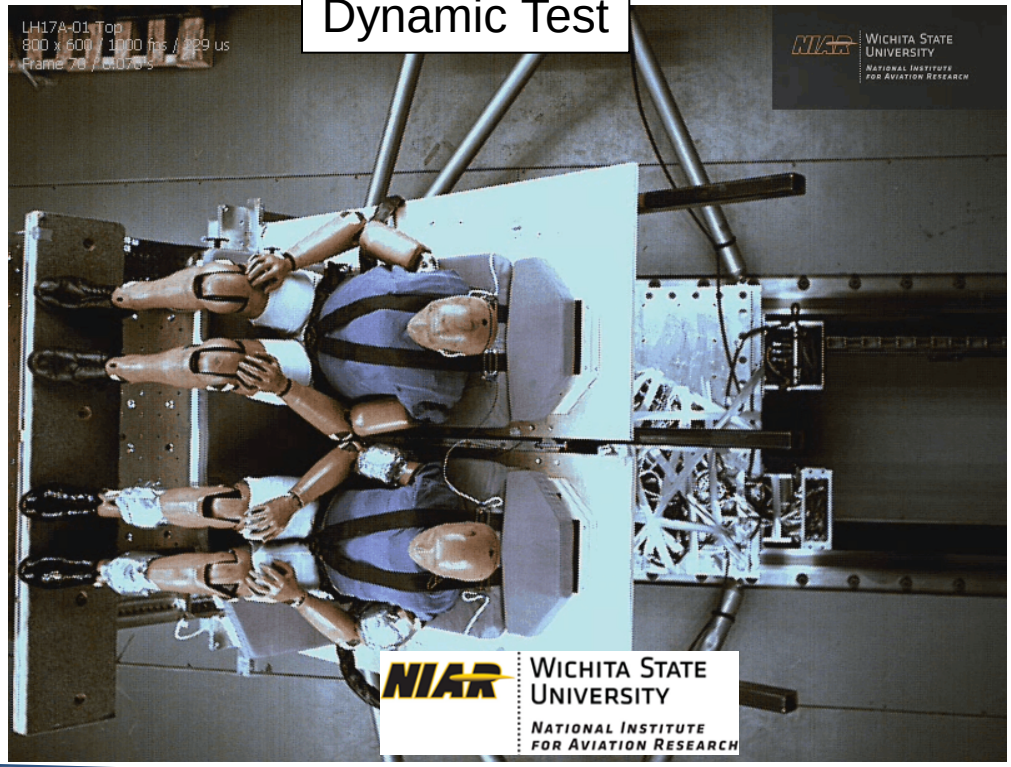
info: Bunk Bed - Double Seat - 14G
obs\BUNKBED\20004\20004.d3plot
Loadcase 1 : Time = 0.000000
Frame 1

F.D.

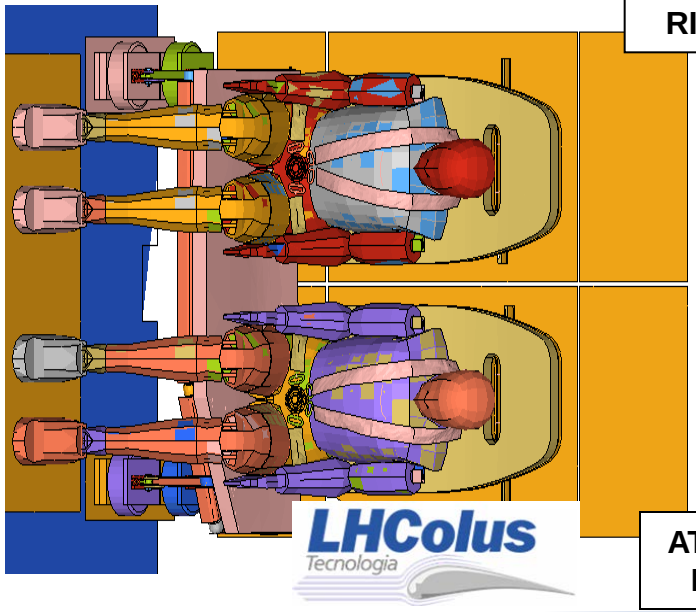


14g Dynamic Test – 14 CRF 25.562

Dynamic Test

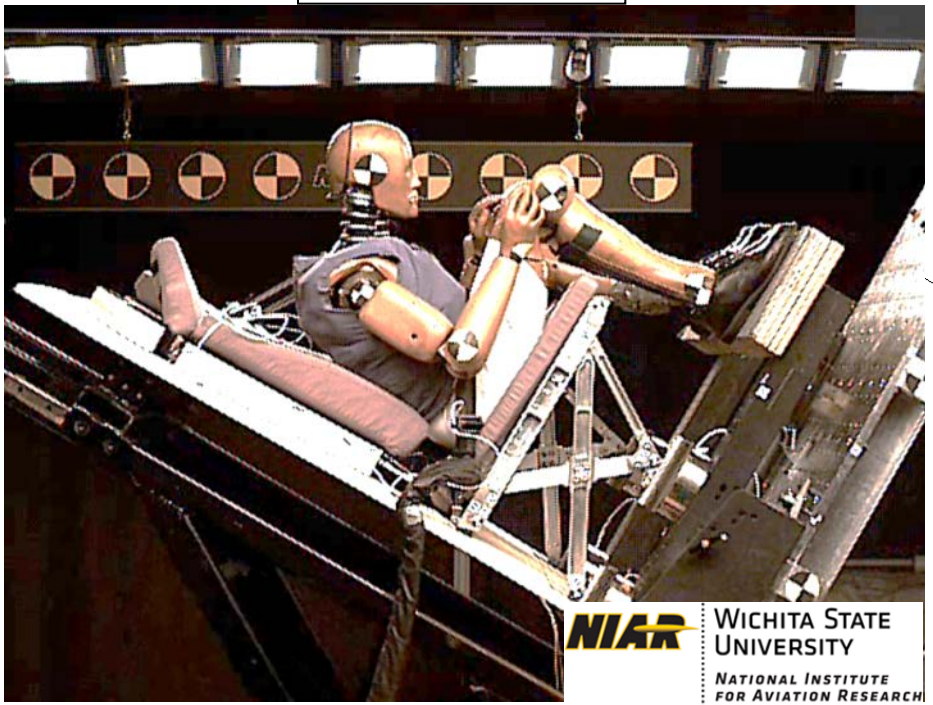


Analysis

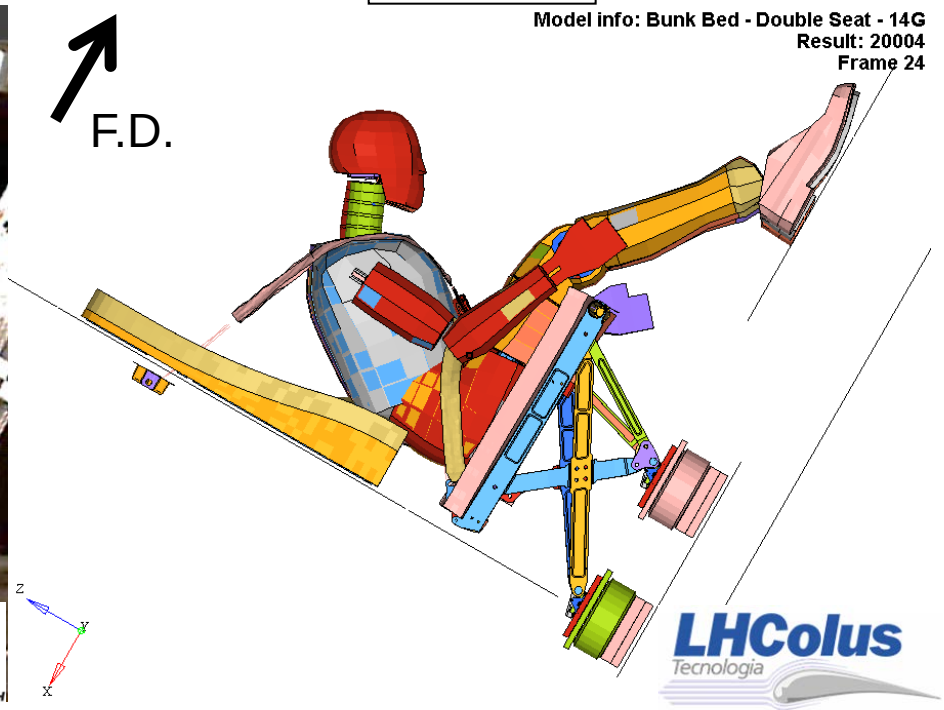


14g Dynamic Test – 14 CRF 25.562

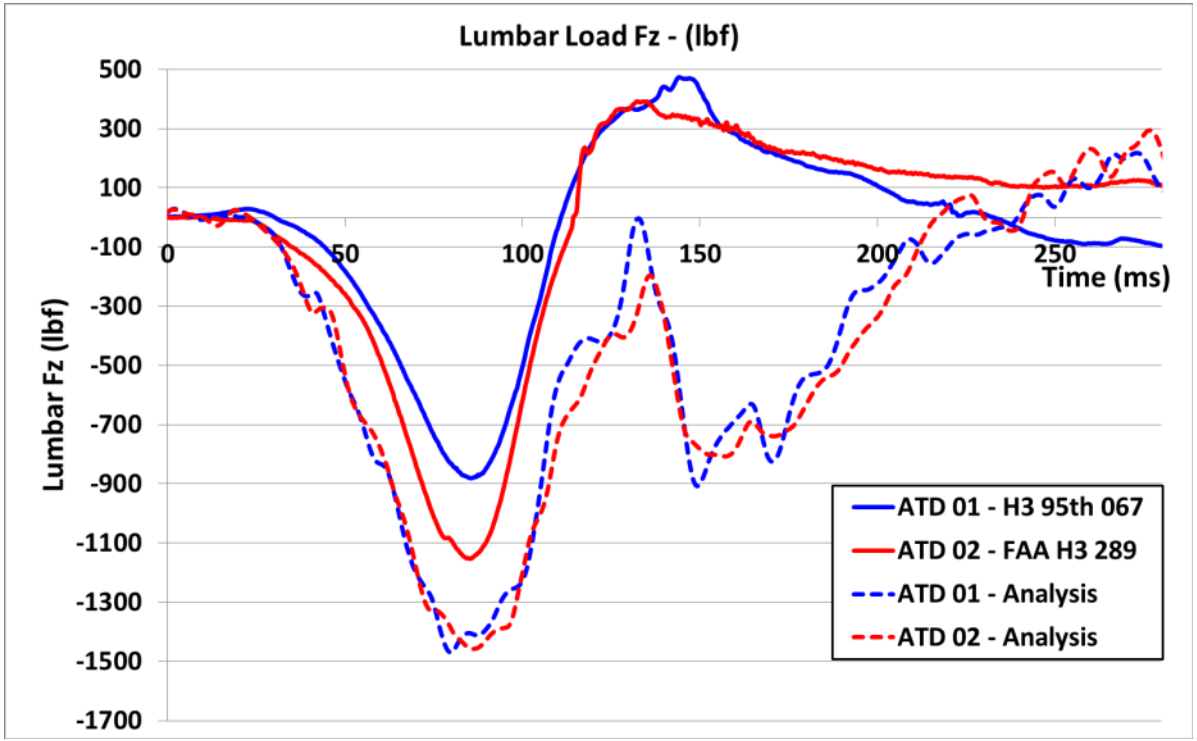
Dynamic Test



Analysis



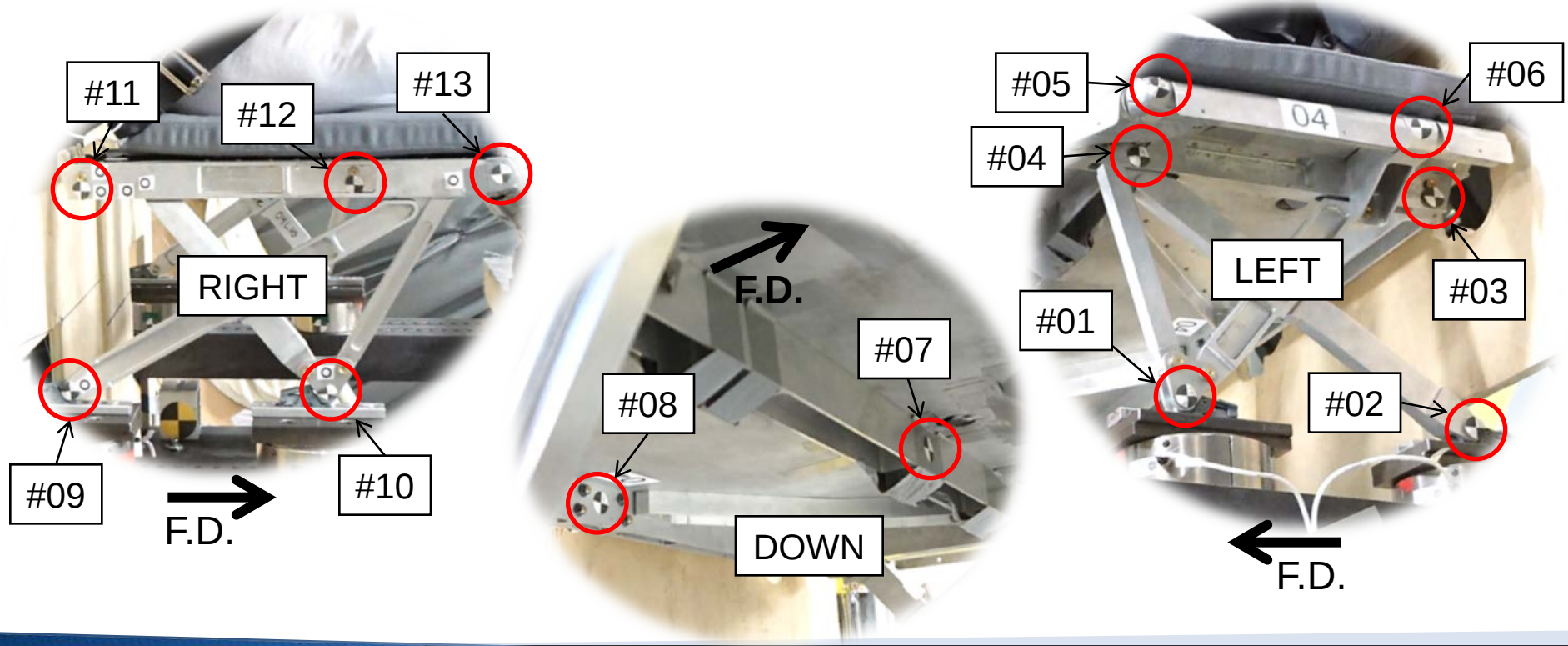
Lumbar Loads 14g – 14 CRF 25.562



Lumbar Load (lbf)			
DUMMY	ANALYSIS	TEST	DIFFERENCE TEST X ANALYSIS
ATD #01	-1457	-880	66%
ATD #02	-1469	-1153	27%

Deformations – 14g & 16g Conditions

Measured points on specimens before and after tests



Deformations – 16g and 14g

16g 25.562 - DEFORMATION DATA				
POINT	DELTA-ANALYSIS (in)	DELTA-TEST (in)	DIFFERENCE	
	RESULTANT	RESULTANT	(in)	(%)
1	0,12	0,07	0,05	72%
2	0,04	0,02	0,02	117%
3	1,14	0,53	0,61	116%
4	1,10	0,53	0,57	108%
5	1,09	0,54	0,56	104%
6	1,10	0,53	0,57	108%
7	1,17	0,56	0,62	110%
8	1,21	0,51	0,70	137%
9	0,10	0,07	0,03	43%
10	0,06	0,02	0,03	149%
11	1,17	0,57	0,61	107%
12	1,04	0,55	0,49	89%
13	1,08	0,58	0,49	85%

14g 25.562- DEFORMATION DATA				
POINT	DELTA-ANALYSIS (in)	DELTA-TEST (in)	DIFFERENCE	
	RESULTANT	RESULTANT	(in)	(%)
1	0,21	0,73	-0,53	-72%
2	0,39	0,86	-0,47	-55%
3	2,41	2,05	0,35	17%
4	1,27	1,95	-0,68	-35%
5	1,63	1,53	0,10	7%
6	1,71	0,78	0,93	118%
7	2,02	2,92	-0,90	-31%
8	0,86	1,66	-0,80	-48%
9	0,06	0,74	-0,68	-92%
10	0,15	0,54	-0,39	-73%
11	3,01	1,93	1,08	56%
12	0,63	2,26	-1,63	-72%
13	1,30	2,97	-1,67	-56%

Double Seat in Operation

Final Considerations

- The overall result of these analyses was very positive, once it was observed a very good correlation with the dynamic test performed and contributing to expedite the product development and qualification.
- The double crew seat was approved in the dynamic tests, complying with all the requirements defined by the 14 CFR § 25.562, including HIC conditions, without any failures.

Thank you!

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